A32: Hygrothermal performance of wood frame walls with low diffusion resistance wind barriers

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About the conference
The following abstract is from the 3rd International Conference on Moisture in Buildings (https://ukcmb.org/icmb25) held in UM Guimarães, Portugal, on the 23-24 Oct 2025. All abstracts published here underwent single blind review by the Conference Scientific Committee.

Abstract

To mitigate climate change there is a need to switch to low-impact materials, including bio-based alternatives substituting conventional materials. However, these materials are more sensitive to moisture induced damage and future climate scenarios predict a warmer and more humid climate. In addition, current best practice guidelines are challenged in terms of using bio-based materials in building constructions. Therefore, the main objective of this study was to demonstrate that it is possible to build bio-based exterior wall constructions that by modelling and experimentally are shown to be moisture-resistant, with low to no risk of mould growth, using low diffusion resistance wind barriers. This was done by comparing hot box – cold box measurements with baseline results from dynamic hygrothermal simulations.
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Keywords: Hygrothermal performance; wood frame wall; vapour retarder, wind barrier; diffusion resistance; bio-based

1. Introduction/Background

Future climate scenarios predict a warmer and more humid climate, with an increase in extreme precipitation events. These changes pose new challenges for the built environment. The construction industry is exploring several low-impact materials, including bio-based alternatives, to help mitigate climate change [1]. While bio-based materials offer environmental benefits they also introduce new challenges. Notably, increased susceptibility to mould growth and introduction of new species typically associated with food spoilage which may thrive at lower relative humidity (RH) and temperature levels [2]. Newer studies have investigated the hygrothermal performance of wood frame walls using bio-based materials, and the relationship between the water vapour diffusion resistance

of the wind barrier and the vapour retarder [3-5]. Results indicate that the Danish best practice recommendation of a ratio of 1:10 between wind barrier and vapour retarder is insufficient and that the ratio increases with decreasing diffusion resistance of the wind barrier. Also, the ratio was found to be dependent on the insulation material, wall U-value, and the indoor moisture load [3]. This study aims to demonstrate that it is possible to build bio-based wall structures that are moisture-resistant, when using low diffusion resistance wind barriers.

2. Methodology

To investigate the hygrothermal performance and potential moisture accumulation in the wood frame walls, a large-scale hot box – cold box setup was utilized. The examined test walls were mounted with sensors (Sonoff SNZB-02P) placed behind the wind barrier. To promote 1-dimensional vapour transport, the sides of each test wall were sealed using a liquid watertightness membrane with a S_d value of 43.5 m. The test walls were positioned in a frame with XPS insulation between and around each wall, and joints were grouted with sealant. The hot- and cold box were conditioned to 20 °C & 58% RH and 0 °C & 86% RH respectively, and the experiment was carried out over a period of 3 months. The wood frame walls include: (W3) wall with 295 mm wood fibre insulation and 9.5 mm gypsum wind barrier (Sd: 0.09); and (W4) wall with 295 mm wood fibre insulation and 30 mm straw board as wind barrier (Sd: 0.14). Both walls had wood exterior claddings and a 25 mm ventilated cavity, and on the interior side a 15 mm OSB4 board as vapour retarder (Sd: 1.46), a 45 mm insulation layer, and internal cladding. Additional information about the test walls is available at [6].

3. Results and Discussion

Figure 1a shows the measured relative humidity (RH) profile behind the wind barrier, and that wall W3 reach potentially critical RH levels (>80%). When measured temperature and RH were used to calculate the moisture content, the levels were rather similar in the two walls (Figure 1b). The red dot illustrates simulated RH with exposed experimental data, for a model which was found to be moisture-resistant with current, warm/humid - and cold future climate conditions. Using the red dot as a baseline indicate wall W4 to be moisture-resistant. Plotting the final RH levels against the Sedlbauer Isopleth curves, suggests that there should be no risk of mould growth (Figure 2a) for W3 and W4. The results were also plotted against sorption isotherms for wood fibre insulation obtained from WUFI (Figure 2b), resulting in the following moisture contents: (W3) 9-14.5 kg/m^3 (20.9-29 weight-%) and (W4) 4.8-6.7 kg/m^3 (10.2-13.4 weight-%). Recommendations suggest maximum 18 ±2 weight-% moisture content to avoid mould growth in wood, suggesting that wall W3 should be at risk of mould growth.

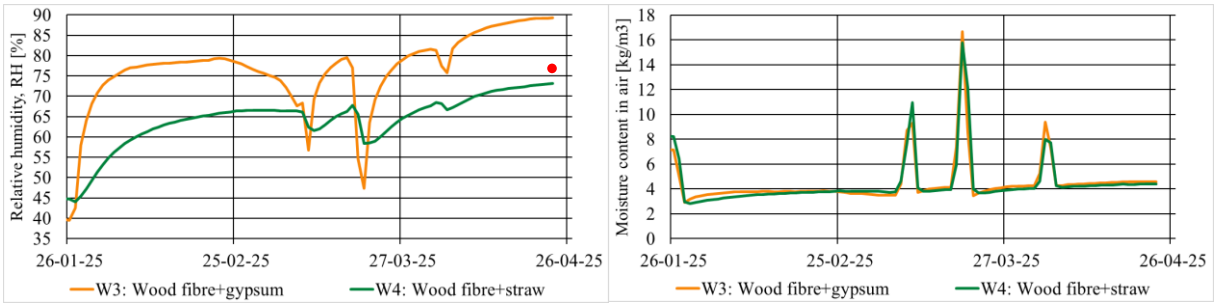

Figure 1. (a) Measured relative humidity behind wind barriers; (b) Calculated moisture content in air behind wind barriers

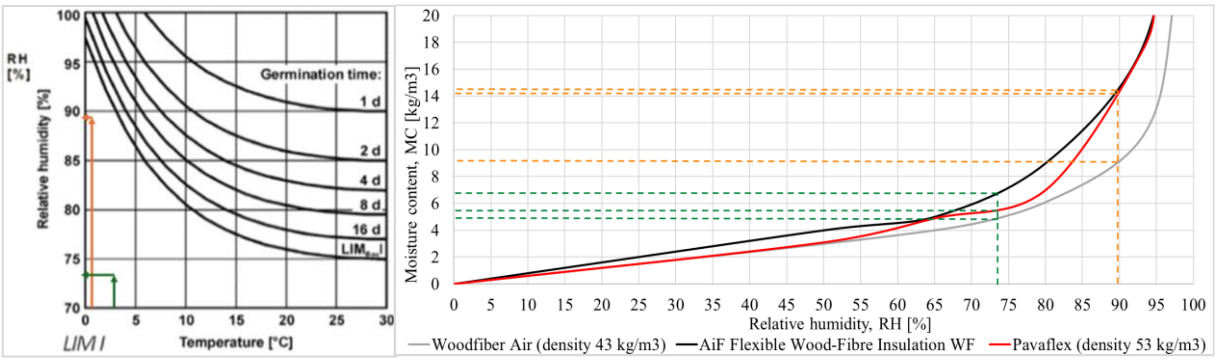

Figure 2. (a) Measured temperature and relative humidity values plotted against the Sedlbauer Isopleth for mould growth on bio-based materials [7]; (b) Wood fiber sorption isotherm from WUFI database, orange: W3 RH, green: W4 RH

4. Conclusion

The hot box – cold box experiment found that wall W3 reach potentially critical RH levels. While wall W4 RH levels were below the simulated baseline defining the moisture level resulting in risk of mould growth. Plotting the results against the Sedlbauer mould Isopleth curves and the sorption isotherms showed contradicting results in terms of risk of mould growth, with the Isopleth curves indicating no risk of mould growth while the isotherms showed risk of mould growth in wall W3 – in agreement with the simulated baseline. However, it is still unclear whether it is temperature and RH or moisture content that drives mould growth. Moreover, due to the nature of materials moisture storage properties the moisture content may vary considerably depending on if it is measured under adsorption or desorption. These uncertainties may hamper the buildability, especially considering future climate conditions. Moreover, there is a need for experimental validations and testing of bio-based materials.

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